



Survival Factors and Biomechanics Factual Report In support of the General Aviation Airbag Study

November 16, 2009

Location: Stigler, OK
Aircraft Type: Cessna 182T
Accident Date: 4/9/2009
Accident Time: 2115Z
Accident Number: CEN09LA247
Airbag Equipped: ☒

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Accident Summary:

On April 9, 2009, approximately 1615 central daylight time, a Cessna 182T, N1491D, was substantially damaged upon collision with terrain following a loss of control during initial takeoff from a private airfield near Stigler, Oklahoma. Visual meteorological conditions prevailed and an instrument flight rules (IFR) flight plan was filed for the Title 14 Code of Federal Regulations Part 91 personal flight. The airplane was owned and operated by a private individual. The 108 nautical mile cross-country

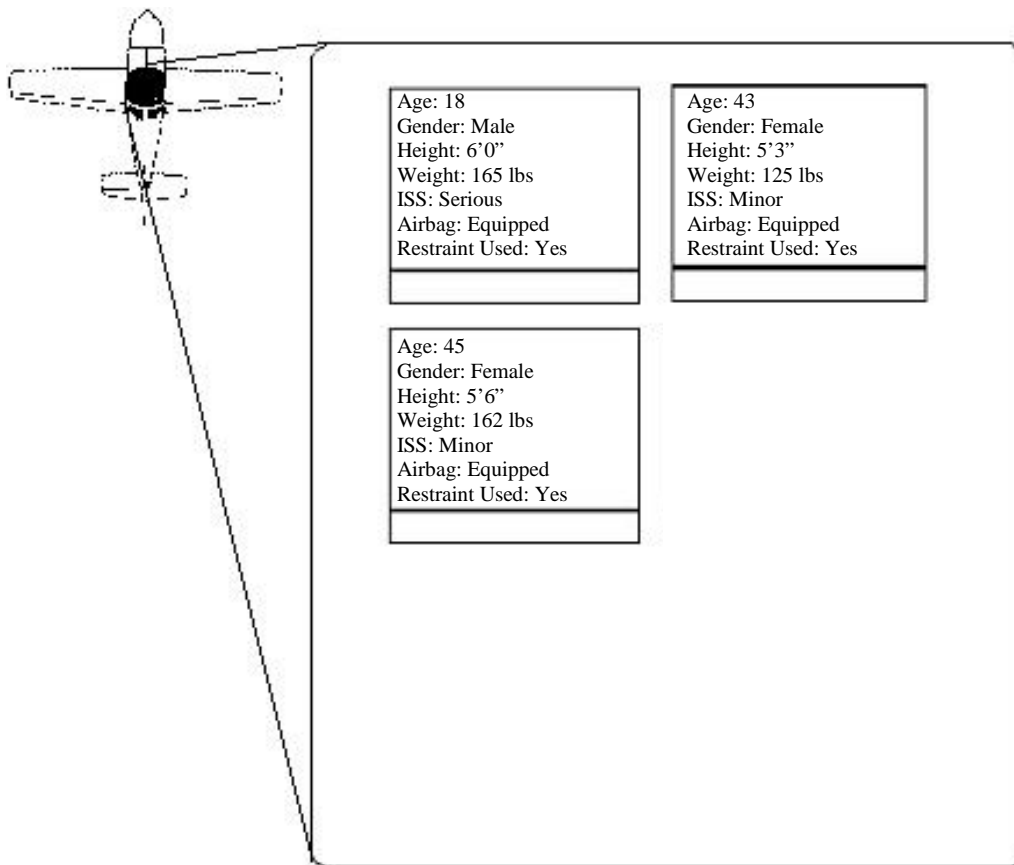
flight was originating at the time of the accident and was destined for the Ardmore Municipal Airport (ADM), Ardmore, Oklahoma.

An initial statement from the passenger, collected by a Federal Aviation Administration (FAA) inspector, stated that during takeoff, the airplane encountered a gust of wind. The pilot lost control of the airplane, collided with terrain and nosed over, coming to rest in the inverted position.

The pilot and two passengers were on board the accident aircraft. The pilot suffered serious injuries, and the right front and left rear passengers suffered minor injuries as a result of the crash.

Abstract:

The survival factors documentation focused on damage to the aircraft fuselage, damage to the cockpit, and the condition of the seats, restraints and the airbags that may have affected the occupants' motion and level of injury. Hospital records were reviewed to document the level and extent of occupant injury. The aircraft was equipped with 3-point lap/shoulder belts at all four seating positions. The lap portion of all four restraint systems was also equipped with an inflatable restraint system (airbag). Aircraft damage patterns indicate that there was impact into the soft ground on the underside of the nose of the aircraft. The right and left wingtips also contacted the ground. During the overturn sequence, the nose, including the engine, separated from the aircraft and the tail was broken and twisted. The instrument panel, control yokes, other control surfaces, the lower center pedestal and the foot wells were displaced upward during the impact sequence. Load marks were noted on the restraint webbing for all three occupant positions. None of the four airbags deployed during the accident sequence. The pilot suffered serious bilateral lower extremity injuries, facial fractures, facial lacerations and multiple abrasions and contusions. The right front passenger suffered minor abrasions and contusions that did not require immediate medical attention. The left rear seated passenger also suffered a minor contusion and laceration.

Seating Chart:**Aircraft Documentation:**

This accident occurred during a soft field takeoff from a 2000' downhill grass runway. With winds gusting from the southeast,¹ the private pilot elected to depart to the north from a private grass strip. During the takeoff sequence, the airplane drifted to the west of the grass strip and the airplane impacted terrain in a crab. The airplane rolled and came to rest in the inverted position. The first marks noted past the runway were likely from the main landing gear, which were approximately 219 feet beyond the estimated point of takeoff.² (See Figure 1.) Ground scars that appeared to be from the left landing gear were approximately 50' long. Additional ground scars likely from the right landing gear were approximately 33' long. Additional ground scars were located along the path to the final rest position. The aircraft's final rest position was approximately 907' from the estimated point of takeoff. The nose and engine were found approximately 30' past the final rest position of the plane and the tail was broken and twisted at final rest. (See Figure 2 and Figure 3.)

¹ Muskogee Municipal Airport (KMKO), Muskogee, OK, located 27 NM north of Stigler, OK, reported weather included: winds from 140° at 22 knots, gusting to 33 knots at the time of the accident. (Source: Cessna.)

² GPS coordinates were taken by the Cessna representative.



Figure 1: A photograph showing the first ground marks off the left side from the runway. (The runway runs approximately along the crest of the hill in the background of the photograph.)



Figure 2: The aircraft was inverted at final rest with the tail twisted and broken and the nose and engine thrown past the final rest position. In the foreground, the two major impacts of the nose into the ground can be seen.



Figure 3: Photographs of the plane at final rest.

The primary impact to the airplane was on the underside of the aircraft's nose. (See Figure 4.) The engine separated from the aircraft and was found approximately 30' past the aircraft's final rest position. The primary impact direction was from the bottom directed upward. Both wing tips showed impact damage but the left wing tip was more heavily damaged. The tail was also broken and twisted. The aircraft came to rest inverted. The hinges on the right passenger door were both broken. On the left door, the upper hinge was broken. (See Figure 5.) The region of the plane incorporating the foot well and the instrument panel was deformed upward at an almost 45 degree angle. (See Figure 6.) In addition, note that in this figure, the top of the instrument panel is at the ceiling of the plane.

After the crash, the left, front passenger released her restraint and fell to the roof. She then unbuckled the pilot and the left, rear passenger and supported each occupant's body as it dropped to the aircraft roof. The two female passengers then assisted the pilot in exiting the aircraft. (See the interview summaries in Attachments 1 and 2.)



Figure 4: This photograph shows the damage to the underside of the nose cone.



Figure 5: Photographs of the left and right side of the plane at final rest position.



Figure 6: Damage to the front of the aircraft can be seen in this photograph looking at the right side of the aircraft. The region of the plane incorporating the foot well and the instrument panel (A) is deformed towards the roof of the airplane at an almost 45 degree angle. In addition, note that the top of the instrument panel is at the ceiling of the plane (B).

Investigators completely removed the right door to gain access to the interior of the aircraft. All four restraints were found in the unbuckled condition. All four seating positions were equipped with airbags. No airbags were deployed. The position of several instrument panel indicators was documented.³ The flap switch was found in the up position. The flaps were in the fully deployed 40 degree down position. The throttle, mixture and propeller controls were full forward. The altimeter was at 100' with a setting of 29.60 in Hg and the airspeed was at 0 knots. The attitude indicator was at 10 degrees nose down and 220 degrees left bank. The cowl flaps were open. The rudder trim indicator and the elevator trim indicator were broken. The flap position indicator was broken. The master switch and the avionics bus were off.

³ Note that the engine was separated from the aircraft and may have affected the positions of the indicators.



Figure 7: A photograph of the instrument panel and left control yoke at final rest position.



Figure 8: Another photograph showing damage to the instrument panel with the photograph rotated upwards.

The deformation to the instrument panel was in and up. (See Figure 7 and Figure 8.) The glare shield and the instrument panel were rotated away from the occupants. The yokes and the top of the instrument panel were near the roof of the plane. Blood marks were noted on the roof predominately on the left (pilot's) side of the plane. The left glare shield was broken. The lower instrument panel was cracked and deformed inward in the

region of the propeller, mixture and flap knobs. On the dimming panel, the knobs were scraped and broken. A scrape was noted on the left bottom corner of the left yoke.

In order to document the displacement of the instrument panel, foot well region and the rudder pedals upward, (see Figure 9) the distance from the top of each rudder pedal to the front edge of the corresponding seat was documented (Table 1). Note that on the left side, the rudder pedals are at the height of the top of the seat pan whereas on the right side, they are below the top of the seat pan. In addition, on the left seat, the sidewall panel was compressed into the footwell/leg region. On the right side, the sidewall panel was essentially intact. For comparison, an exemplar photograph of a Cessna interior is shown in Figure 10.

Table 1: Measurements documenting the deformation of the forward portion of the plane upward toward the roof of the plane. All measurements are parallel to the longitudinal axis of the plane.

Distance from top of rudder pedal to front edge of seat	Distance (in)
Left Seat	
Right rudder	7.5"
Left rudder	11.0"
Right Seat	
Right rudder	19.0"
Left rudder	18.50"



Figure 9: A photograph showing the damage to the footwell region and rudder pedals on the pilot's side.



Figure 10: An exemplar photograph of the Cessna interior.⁴

Seats

The pilot's seat was found in the 1st pin position (full forward). The passenger seat was in the 9th pin back from full forward. There were 14 total pin positions for each front seat. Damage was also noted to the front edge of the pilot's seat track and can be seen in Figure 11. General dimensions of the seats in the first row are shown in Figure 12. The seats are assembled by Cessna and are not specifically marked with any tracking numbers.



Figure 11: Damage to the front edge of the pilot's seat track.

⁴ <http://marc.merlins.org/blogmedia/C182-g1000.jpg> on April 30, 2009.

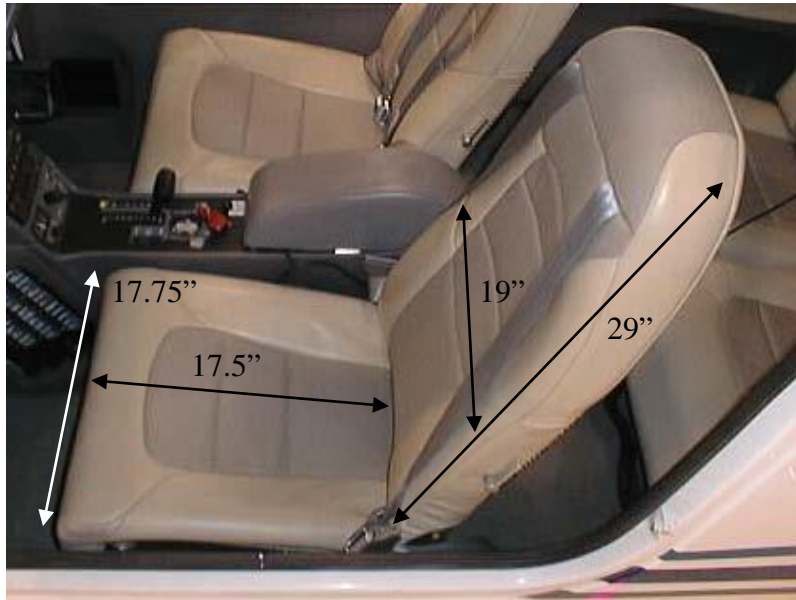


Figure 12: Dimensions of the 1st row seats (displayed on a generic general aviation seat).

Restraints:

All four seating positions were equipped with 3-point lap/shoulder belts. All four seats were equipped with an inflatable restraint (airbag) in the lap portion of the belt. A photograph showing an exemplar lap/shoulder belt equipped seat with the airbag stowed in the lap portion of the belt is shown in Figure 13. For both the pilot's seat and the front passenger seat, the attachment points for the lap and shoulder portions of the belt were on the inboard side of the seat while the seat belt buckle was on the outboard side of the seat. For the two rear passenger seats, the buckles were on the inboard side (i.e., both buckles are between the two seats). (See Figure 14.) Two sets of buckles were noted in the rear seats. (See Figure 15.) The secondary buckles were labeled Auxiliary Child Seat Buckles with an additional warning concerning the airbag system. That label can be seen in Figure 16.

Both the left and right front seat restraint inertia reels were functional, post-accident but the webbing in the right front restraint would not fully retract into the reel. The inertia reels were functioning properly for the two rear seats. Prior to moving the accident aircraft, the restraint systems were examined to document latch position and potential load marks. The distance from the anchor bolt to the load bar for all four seat positions in the post accident position is detailed in Table 2. Note that for the rear seats, the anchor bolt was inaccessible, and therefore the cushion reference point, the point where the belt emerges from the cushion, was used as the reference for those measurements. Load marks were found under the load bar in all seating positions except the right, rear seat. The front seating positions exhibited heavier load marks than the left, rear seating position. The position of the belt on the left rear seat when the load bar was placed over the load marks is shown in Figure 17. The restraint identification numbers are shown in Figure 18.

Table 2: The position of the load bar for all four seating positions.

Seat Position	Distance
Right, front seat	34"
Left, front seat	35.5"
Right, rear seat(unoccupied)	27"
Left, rear seat	37"

Note: For the front seats, the measurement was taken between the anchor bolt and the load bar. For the rear seats, the measurement was taken between origin of the webbing at the cushion and the load bar.



Figure 13: A photograph showing a general aviation seat equipped with a lap/shoulder belt and an inflatable restraint system (airbag) in the lap portion of the belt.⁵

⁵ AmSafe Aviation, <http://www.amsafe.com/products/detail.php?id=68&type=categories> on February 2, 2009.



Figure 14: A photograph of the interior of an exemplar Cessna 182.⁶



Figure 15: The primary (top) and secondary (bottom) buckles for the rear seat occupants can be seen in this photograph.

⁶ http://www.cessna.com/MungoBlobs/87/548/sin_lan_int02_hires.jpg on April 20, 2009.



Figure 16: A photograph of the label stitched to one of the secondary buckles in the rear seat.



Figure 17: The photograph shows the left rear seat with the restraint fastened in the post-accident position. Load marks were found under the load bar in this position.

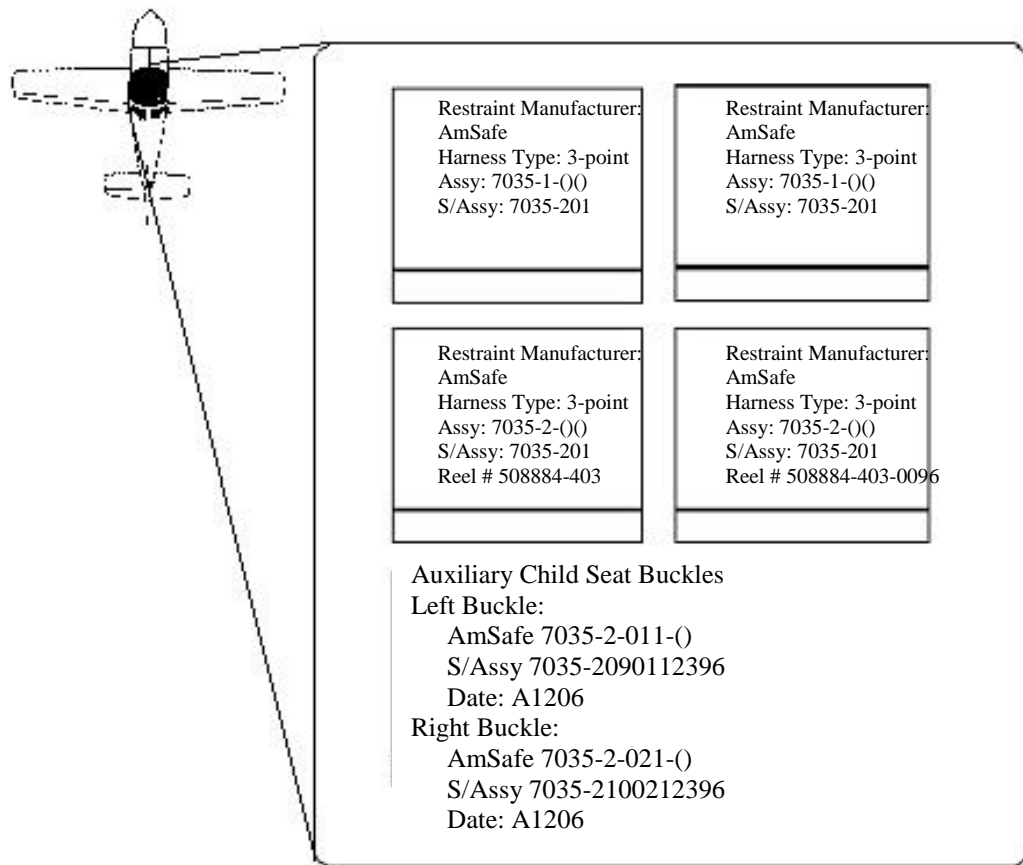


Figure 18: Restraint identification numbers.

Blood marks were also noted in several places on the restraint webbing and on the seats. On the left, front seat restraint, a small blood mark was noted at the cover attachment to the webbing. Extensive blood marks were also noted extending from 36" to 48" from the load mark along the shoulder harness on the webbing. The right front seat restraint had a faint blood mark about 10.5" from the webbing load mark and also a diffuse blood mark extending from 26" to 32" from the load mark along the shoulder harness. A small blood mark was noted next to the seat cushion near the buckle for the left, rear passenger seat.

Airbags:

The Cessna aircraft was equipped with 3-point lap/shoulder belts in all four seating positions. All four positions were also equipped with the inflatable restraint system or airbag, which was contained within the lap portion of the restraint. This airbag system has a latch sensor, which is activated when the seatbelt is connected.

None of the four airbag systems deployed during the crash. The airbag systems were examined prior to moving the aircraft from its final rest position. Examination of all four systems revealed that the inflator, the cable harness to the buckle switch, and the gas hose were all connected. Two Electronics Module Assemblies (EMA) were present

in this plane, one for the front seats and another for the rear seats. The EMA is the crash sensor which triggers airbag deployment when a certain threshold is met.⁷ The EMA connects to the cable harness which then splits to each seat's airbag system. This connection was intact for both the front and rear seats.

An AmSafe developed diagnostic test tool (P/N 508668-201) was used to assess the condition of the airbag system. The diagnostic tool was connected to each airbag system to assess whether the system was active and enabled. A green light indicates that the system is active and enabled. For all four airbags, the diagnostic tool showed a green light indicating that the system was active and enabled. (See Figure 19.) When the belt was fastened into the auxiliary child seat buckles, neither rear seat airbag was enabled. (See Figure 20.) In addition, in a previous investigation, it was noted that the front seat belts could potentially be switched such that the belt for the right seat occupant was actually used by the left seat occupant. This case was tested with the diagnostic tool and showed that the airbag system for the left seat occupant would still be active and enabled except that the airbag would have deployed from the unused belt.

Each airbag system was manually disabled by the AmSafe representative prior to examination of the aircraft interior. Because the airbags did not deploy, no further documentation of the airbags was performed. The EMAs for the front and rear seats were removed and were shipped to AmSafe Aviation in Phoenix, Arizona for further testing to verify that they were within design specifications. On June 22, 2009, a thruster test was performed on each unit to verify that the crash sensor and firing signal were within production specifications. The thruster is a machine that applies impact acceleration to the EMA and measures the output signal of the EMA. Both EMAs passed the test, indicating that their performance was within production specifications. (See Attachment 3.)

⁷ The sensor threshold is a function of the impact acceleration and velocity change.



Figure 19: This photograph shows the testing of the airbag system for the left, rear seat. The diagnostic tool shows a green light indicating that the airbag system was active and enabled. (Note that the airbag systems were examined prior to moving the aircraft from its final rest position.)



Figure 20: This photograph shows the testing of the airbag system for the left, rear seat using the auxiliary child seat buckles. The diagnostic tool shows three orange lights indicating that the airbag system was not active or enabled. (Note that the airbag systems were examined prior to moving the aircraft from its final rest position.)

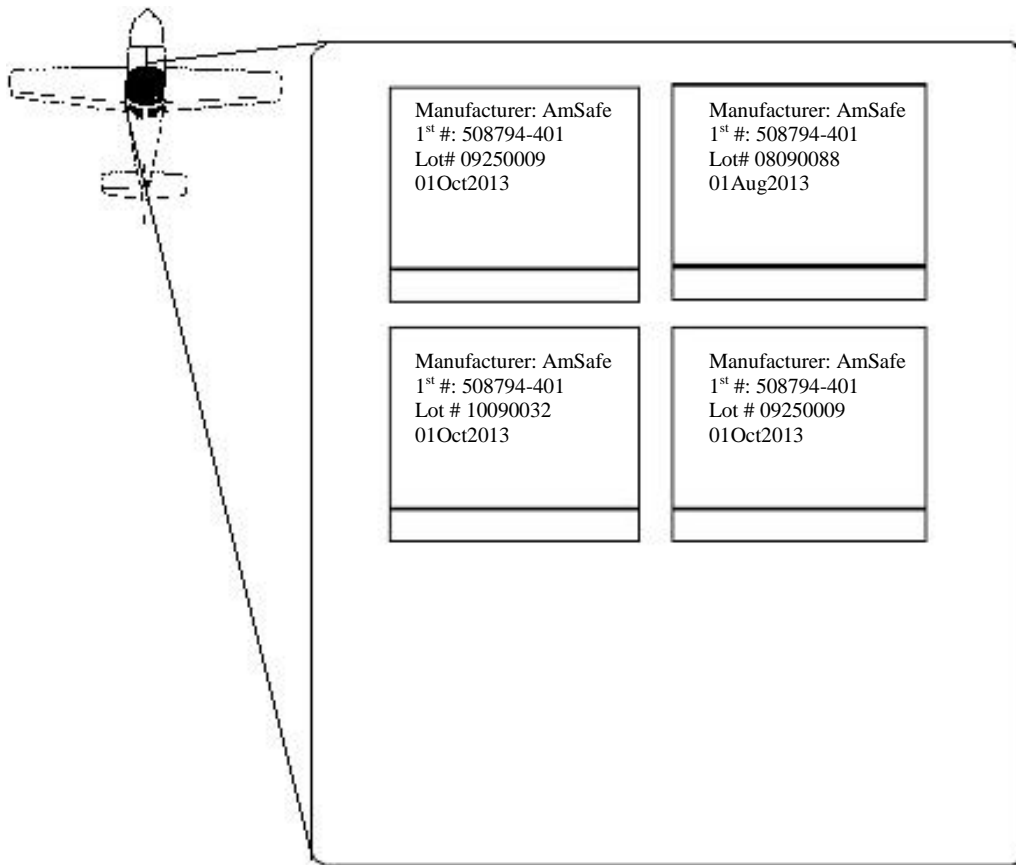


Figure 21: Airbag labels.

Medical Information:

The male occupant, the pilot, in the 1st row on the left side was treated at St. John Medical Center in Tulsa, OK. The occupant in the 1st row, right seat visited her personal doctor the day after the crash. The occupant in the 2nd row, left seat was treated and released at Stigler Regional Hospital. The occupant seating location, gender, age, height, weight and injuries are listed in Table 3 below. Figure 22 through Figure 24 are diagrams showing the injury locations on a body image.

Table 3: A table of the occupant injury description and classification.

Occupant Location	Gender	Age	Height	Weight	Description Of Injuries	Injury Classification
1 st Row, Left	M	18	6'0"	165 lbs	Left fibula fracture, non-displaced left ankle fracture, right lateral malleolus fracture, non-displaced right calcaneus and talus fracture, right orbital wall fracture, right zygomatic fracture, right maxillary sinus fracture, facial lacerations, right eye contusion, upper and lower lip contusion, bilateral knee abrasions	Serious
1 st Row, Right	F	43	5'3"	125 lbs	Contusions on left shoulder and left side of neck, contusions and abrasions on right hip	Minor
2 nd Row, Left	F	45	5'6"	162 lbs	Left knee contusion, anterior left ankle laceration	Minor

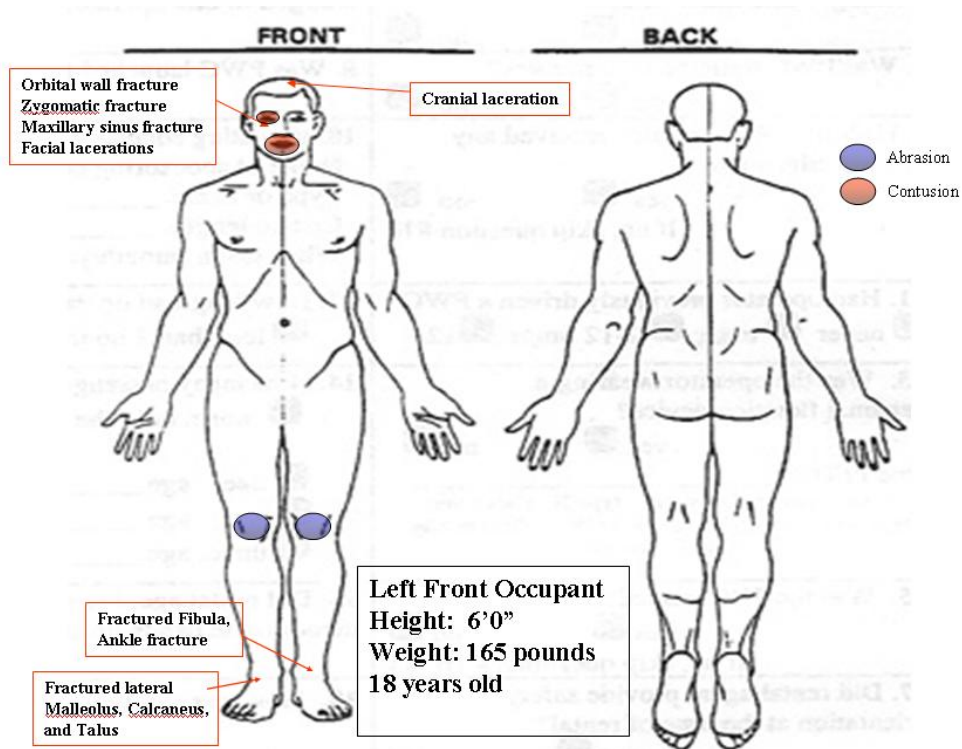


Figure 22: A diagram showing the injury locations for the pilot.

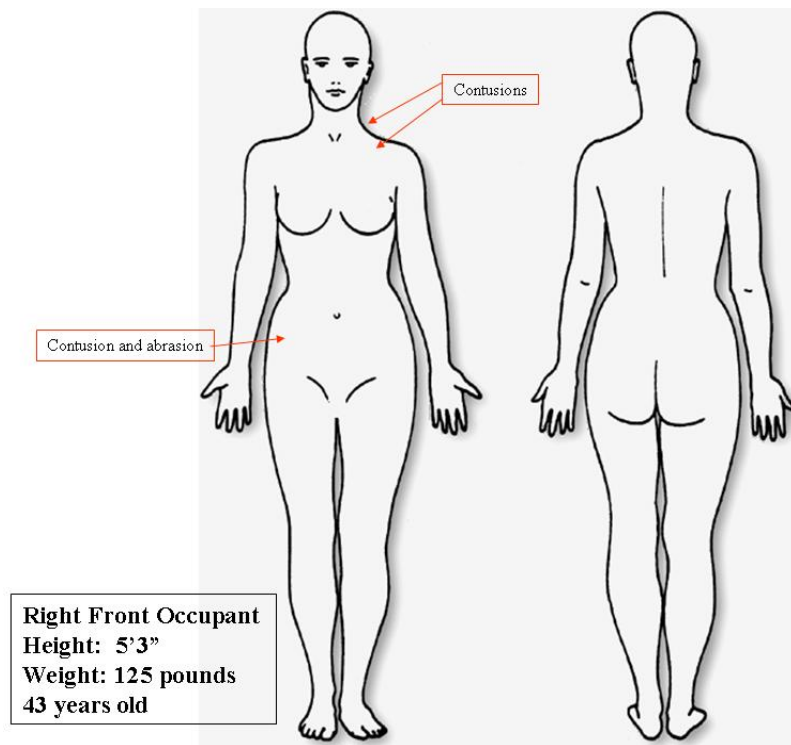


Figure 23: A diagram showing the injury locations for the right front occupant.

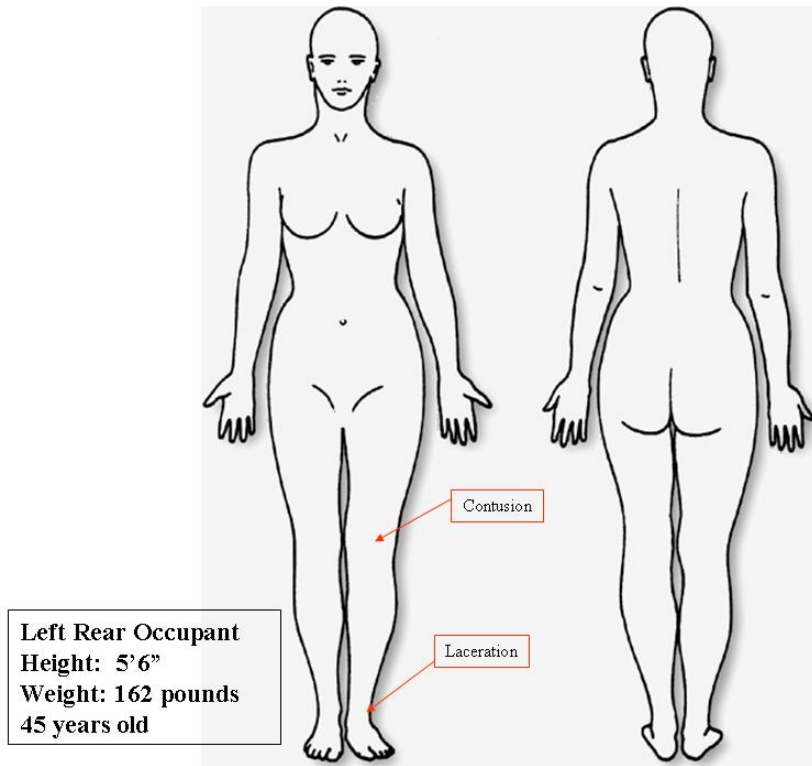


Figure 24: A diagram showing the injury locations for the Left rear occupant.

Attachment 1: Interview with female occupant in the first row, right side

This passenger stated that her height and weight were 5'3" and 125 lbs. She was unaware that the plane was equipped with seat belt mounted airbags. She explained that she had been in a rollover accident in a Ford Explorer noting that she sustained injuries in that crash from tensing up during the rollover. So, during this plane crash, she told herself to remain calm. She said that she was seated in the front row on the right side.

She remembered the pilot loading some items into the rear cargo region. The pilot then put his mother in the back seat, behind the pilot seat. (He had slid the right seat all the way forward to allow his mother to access the rear seats.) Once this passenger got into the right, front seat, she slid the seat back, away from the controls. The pilot instructed the passengers how to fasten their belts and made sure they were tight. This passenger noted that she first reached to the right for her belt, as in a passenger vehicle, but that the pilot then directed her to the center of the plane for her belt. She put the headset on; her purse between her feet and her phone on her lap.

They started taxiing and gaining speed. She could feel the wind shake the whole plane. She could see the ground and then felt the plane hit the ground but was trying to stay calm. She then remembered hanging upside down in the air. Her right leg was caught under the seat and she had to rip her pant leg to release her leg. She saw that the pilot had blood coming from his face and he was moaning. The pilot's mother, in the rear seat, was worried about her son. This passenger then reached over and released her belt. (She said it was difficult to release.) She fell onto the roof, hard. She crawled over to the pilot and unlatched his belt while supporting his weight on her back so that he wouldn't fall as well. She then rolled him off her back. She then released the rear occupant's belt in the same manner, supporting her weight to the roof. She and the rear passenger helped the pilot egress. They crawled out a hole in the front of the plane but she wasn't sure if it was a door or the windshield region.

The neighbors came out to help and then she looked for a cell phone to call the plane owner, who was also the pilot's father.

She stated that she had a raw spot on her right hip and that she was bruised on her left shoulder. She had pain in her left shoulder and along the left side of her neck, extending down her back. She had a hard time walking on her right leg. She visited her personal doctor the day after the crash, based on the plane owner's urging.

Attachment 2: Interview with male pilot and female occupant in the second row, left side**Stigler, OK: Interview with Pilot: 4/24/2009**

This individual has been a pilot for 2 years and has a private and instrument rating. He has approximately 175 flight hours of flight time. Due to a concussion and amnesia, he does not remember much from the flight. For a preflight, he ran through the Cessna checklist and made sure that each passenger knew to buckle up. He got the flight plan from FlightWatch. He indicated that he was not confused by the auxiliary buckles in the rear seats. He sustained a fractured right cheek bone (and black eye on right side), fractured fibula in left foot, fractured heel in right foot, Also, cuts on the very top of his head (no stitches). He does not wear glasses.

Interview with rear left seat occupant: 4/24/2009

This passenger entered the back seat of the plane from the right side. (She usually sits up front.) She pulled the seatbelt down and snapped it tight. She has been “flying a long time” (not a pilot, but took ground school and some flight lessons) and is a big seatbelt advocate. The pilot had the seat scooted up so she could enter. The pilot then helped the front, right seat occupant enter the plane. The pilot helped to secure her restraint as well.

She remembers the pilot taking off and then touching down for a second and taking off again. Then the plane stalled and the wind changed direction. She noticed the wind was coming from the left and heard the stall warning one time and thought it was unusual to hear it that quick. She could feel the pilot correcting the airplane from the left and she looked at the pilot and he seemed calm. Then all she remembers was that the plane had crashed. The front, right seated passenger unbuckled her after the crash. (She could reach the button but couldn’t push it hard enough to get it unlatched.) She thinks that they exited the plane on the passenger’s side. She hit her left knee on the inside and it left a bruise. She also had a cut on the top of her left ankle/shin, which bled a little. She went to the hospital and was checked out (Stigler Regional).

Attachment 3: EMA Thruster Test Report